

PRELIMINARY DATA SUMMARY

March 1993

U.S. Army Engineer Waterways Experiment Station
Coastal Engineering Research Center
Field Research Facility
Duck, North Carolina

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CERC Field Research Facility
Duck, North Carolina

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

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PART I: INTRODUCTION

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.6 m above the National Geodetic Vertical Datum (NGVD) of the year 1929. In addition, a main building contains offices, an instrument repair shop, and a data acquisition room.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local oceanographic and meteorological conditions. Bottom profiles along both sides of the pier and periodic bathymetric surveys are also performed.

This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511.

Part II presents the meteorological data; Parts III through VI present oceanographic data; Part VII presents nearshore profiles and bathymetry; and Part VIII, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used, their operational status during the month, and the data collection status. Figure 2 identifies the location of the instruments. The water depths at the wave gages and current meters vary and may be determined from information contained in Figure 7. Other installation information is contained in Table 1.

Times given in the report, unless otherwise specified, are referenced to eastern standard time (EST).

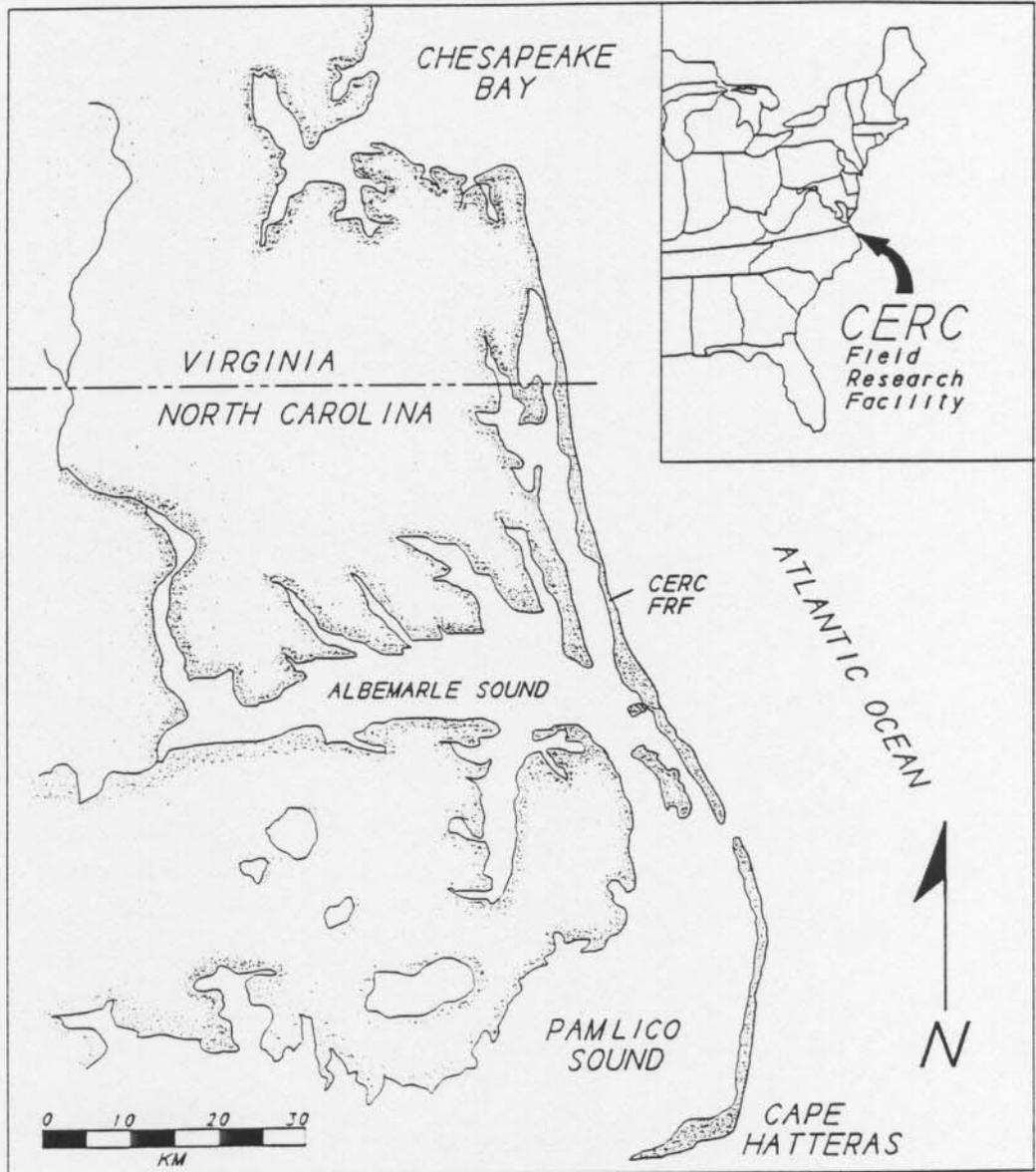


Figure 1. FRF Location Map

Table 1: Instrument Status/Data Availability

March 1993

Gage ID	Description/Remarks	Depth at Sensor		Day of the month																														
				1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	2	2	2	2	2	2	3	3	
616	Barometric Pressure		Gage Status	*																														
			Data Collected	*																														
604	Precipitation		Gage Status	*																														
			Data Collected	*																														
624	Air Temperature		Gage Status	*																														
			Data Collected	*																														
932	Anemometer at seaward end of pier Elevation 19 m (NGVD)		Gage Status	*																														
			Data Collected	*																														
625	Baylor staff at station 18+60 on FRF pier	see Figure 7	Gage Status	*																														
			Data Collected	*																														
511	Pressure gage 243 m north of FRF pier (0.9 km offshore)	Approx. 7.9 m NGVD	Gage Status	*																														
			Data Collected	*																														
630	Waverider buoy 4.0 km offshore	Approx. 17 m NGVD	Gage Status	*																														
			Data Collected	/ / / / *	*																													
519	Current meter 320 m north of FRF pier (0.9 km offshore)	see Figure 7	Gage Status	*																														
			Data Collected	*																														
865-1370	NOAA tide station at seaward end of FRF pier		Gage Status	*																														
			Data Collected	* * * / / *	*																													
Supplemental Observations (daily oceanographic and meteorological observations)			Daily observation	*																														

Gage Status
Operational = *
Partial = /
Non-Operational = -

Daily Observation
Complete = *
Partial = /
None = -

Data Collected
All = *
Partial = /
None = -

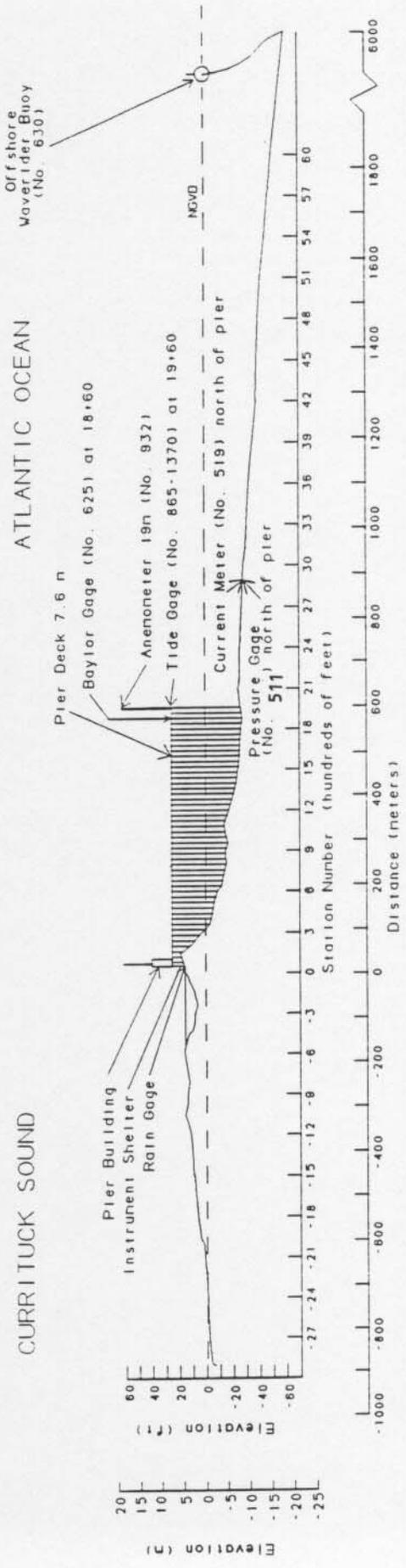
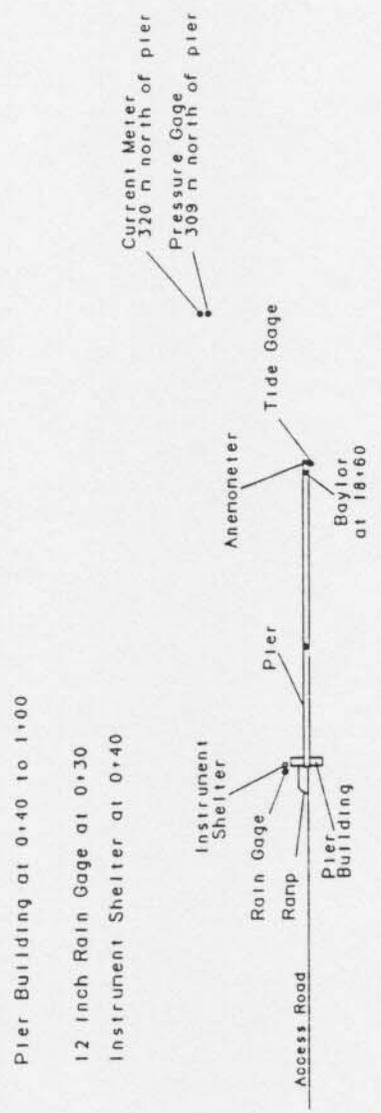


Figure 2. Instrument locations at FRF (all elevations from NGVD, all distances from FRF baseline).

PART II: METEOROLOGICAL DATA

A variety of instruments have been installed at the FRF (Figure 2) to monitor the meteorological conditions. The data presented in Table 2 are collected and stored using a Digital Equipment Corporation VAX 11/750. For each instrument identified in Table 1 as having analog outputs, chart records are obtained, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m (Figure 2) using a WeatherMeasure Skyvane anemometer.

Monthly resultant wind speeds and directions are determined by vector averaging the data. Wind directions indicate where the wind is coming from. Temperature and atmospheric pressure means are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 2 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $\text{mm} \times .03937 = \text{in.}$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $\text{mb} \times 0.02953 = \text{in. Hg}$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(\text{C} \times 9/5) + 32 = \text{F}$
4. Meters per second (m/s) to knots (kn) -
 $\text{m/s} \times 1.943 = \text{kn}$

Table 2: Meteorological Data

Mar 1993

Day	Hour	Wind	Wind	Temperature	Atm	Precipitation
		Speed	Direction	deg C	Pressure	mm
		m/sec	deg TN		mb	
1	100	6	325	0.7	1018.6	0
	700	5	325	-0.2	1019.1	0
	1300	6	10	5.2	1017.1	0
	1900	3	238	5.3	1015.1	0
2	100	4	212	5.4	1013.1	0
	700	6	239	4.9	1012.5	0
	1300	4	226	12.3	1010.4	0
	1900	3	247	9.9	1010.1	0
3	100	4	215	10.1	1010.4	0
	700	3	251	13.9	1012.7	0
	1300	1	190	12.0	1012.0	0
	1900	6	128	12.1	1012.1	4
4	100	8	49	12.1	1008.3	18
	700	9	132	12.5	1000.5	3
	1300	10	214	17.6	994.6	8
	1900	7	186	11.6	999.5	0
5	100	6	218	9.9	1002.3	0
	700	5	195	8.8	1003.0	0
	1300	7	249	12.9	1000.8	0
	1900	7	266	10.3	1003.5	0
6	100	7	286	6.3	1007.4	0
	700	7	283	4.5	1010.5	0
	1300	6	232	9.3	1011.4	0
	1900	3	38	5.5	1013.8	0
7	100	3	1	6.0	1015.5	0
	700	4	57	7.2	1016.5	0
	1300	5	124	9.3	1015.7	0
	1900	6	154	6.9	1011.8	0
8	100	6	218	9.9	1008.9	0
	700	7	239	9.6	1008.6	0
	1300	5	250	16.1	1006.0	0
	1900	6	277	14.2	1006.5	0
9	100	5	279	11.1	1010.5	0
	700	8	284	8.2	1012.4	0
	1300	7	287	13.1	1013.2	0
	1900	2	321	8.9	1015.4	0
10	100	4	42	6.8	1017.4	0
	700	5	71	7.1	1016.2	0
	1300	6	150	10.0	1009.7	0
	1900	12	205	16.7	1001.0	0
11	100	1	153	7.5	1006.7	0
	700	3	268	7.9	1011.1	0
	1300	6	278	13.5	1012.1	0
	1900	7	32	7.0	1016.5	0
12	100	8	29	4.7	1020.2	0
	700	6	55	4.3	1022.1	0
	1300	5	59	6.1	1021.5	0
	1900	10	62	5.6	1018.8	0
13	100	14	53	5.8	1010.3	0
	700	10	127	9.4	992.1	7
	1300	15	180	16.5	971.1	50
	1900	20	215	6.8	972.0	0
14	100	18	255	0.7	986.8	0
	700	16	271	-0.2	1002.9	0
	1300	13	262	2.3	1009.4	0
	1900	9	292	0.7	1016.5	0
15	100	9	304	-2.0	1024.5	0
	700	9	326	-2.6	1031.0	0
	1300	3	25	0.8	1034.3	0
	1900	3	1	-0.6	1035.6	0
16	100	4	168	-0.5	1036.1	0
	700	1	1	2.9	1036.6	0
	1300	7	125	10.4	1033.9	0
	1900	5	149	8.7	1030.5	0

* electronic problems

(Continued)

(Sheet 1 of 2)

Table 2: Meteorological Data

Mar 1993

Day	Hour	Wind Speed	Wind Direction	Temperature	Atm Pressure	Precipitation
		m/sec	deg TN	deg C	mb	mm
17	100	4	150	8.7	1027.1	0
	700	5	148	9.1	1023.2	0
	1300	12	171	18.4	1017.0	0
	1900	5	288	12.0	1013.6	8
18	100	17	349	3.9	1017.0	6
	700	18	1	0.6	1022.2	0
	1300	13	2	-0.2	1027.4	0
	1900	13	17	0.2	1029.5	0
19	100	13	26	1.2	1030.6	0
	700	11	37	2.4	1032.3	0
	1300	10	22	3.6	1033.6	0
	1900	10	10	3.0	1033.4	0
20	100	9	23	3.4	1031.5	0
	700	7	49	4.8	1030.3	0
	1300	5	24	5.8	1029.3	0
	1900	6	44	4.6	1027.8	0
21	100	2	1	4.8	1025.7	0
	700	3	12	5.1	1025.3	0
	1300	3	101	9.1	1024.8	0
	1900	5	99	6.2	1024.7	0
22	100	0		4.3	1025.5	0
	700	3	21	6.2	1027.1	0
	1300	3	77	10.4	1027.7	0
	1900	6	75	7.6	1026.6	0
23	100	7	79	7.9	1026.3	0
	700	7	83	8.2	1026.5	0
	1300	5	141	10.9	1025.3	0
	1900	6	154	9.2	1022.9	0
24	100	7	154	9.0	1020.0	0
	700	5	147	8.6	1017.0	0
	1300	1	176	12.1	1016.0	6
	1900	3	81	8.6	1015.3	0
25	100	6	3	7.4	1017.3	0
	700	9	16	5.5	1019.3	0
	1300	9	22	6.5	1020.4	0
	1900	5	36	5.8	1021.2	0
26	100	3	20	6.1	1021.2	0
	700	3	16	6.3	1021.4	0
	1300	6	11	7.9	1020.4	0
	1900	7	39	7.0	1018.5	0
27	100	9	47	7.4	1015.1	0
	700	12	68	8.9	1011.2	0
	1300	6	94	11.0	1009.1	11
	1900	5	139	9.4	1007.3	0
28	100	5	193	13.4	1007.3	0
	700	4	207	11.7	1007.9	0
	1300	1	1	14.0	1007.5	0
	1900	3	160	11.5	1007.1	0
29	100	0		8.8	1006.3	0
	700	2	304	12.0	1005.9	0
	1300	2	94	11.4	1004.5	0
	1900	2	254	12.0	1005.2	0
30	100	5	271	12.3	1004.1	0
	700	7	299	12.4	1005.0	0
	1300	6	1	12.6	1006.3	0
	1900	4	30	10.1	1008.4	0
31	100	2	265	12.0	1010.0	0
	700	5	94	8.4	1011.5	0
	1300	5	106	12.3	1011.5	0
	1900	3	291	10.2	1008.1	0
		<u>Resultant</u>		<u>Mean</u>	<u>Mean</u>	<u>Total</u>
		1	10	7.9	1015.1	121

* electronic problems

PART III: WAVE DATA

Wave data are collected from a Baylor staff gage (Gage 625), a pressure wave gage (Gage 511) and a Waverider buoy (Gage 630) as shown in Table 1 and Figure 2. The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAX 11/750 programmed to sample the wave gages every 3 hr. The sampling rate is two times per second for five contiguous 34-min records. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record.

Wave height H_{m0} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gage has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 deg of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum. When this analysis is complete, the data are written to optical disc.

Table 3 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 3 are average values computed from this data. Figure 3 is a time history of all H_{m0} and T_p values obtained for all gages.

Differences in wave periods between wave gages (Table 3 and Figure 3) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

Table 3: Wave Data

Mar 1993

Day	Hour	625		511		630	
		Baylor at 18+60		Pressure Gage		Offshr	Wvrdr
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec
1	0100	2.56	15.06	2.83	15.06	2.52	6.24
	0700	2.58	14.22	2.97	14.22	2.55	21.33
	1300	2.53	15.06	2.77	14.22		*
	1900	2.29	15.06	2.60	14.22		*
2	0100	2.04	14.22	2.01	15.06		*
	0700	1.32	13.47	1.23	13.47		*
	1300	0.88	11.64	0.94	12.80		*
	1900	0.79	12.80	0.81	12.19		*
3	0100	0.56	11.13	0.71	11.13		*
	0700	0.52	11.64	0.56	11.64		*
	1300	0.44	11.64	0.52	12.19	0.57	11.13
	1900	0.47	11.64	0.50	12.19	0.48	11.13
4	0100	0.66	3.20	0.54	12.19	0.70	11.64
	0700	1.08	5.02	1.04	5.02	1.25	4.74
	1300	1.40	6.09	1.46	8.83	1.73	9.48
	1900	1.16	9.85	1.22	8.00	1.02	9.48
5	0100	1.20	9.48	1.24	8.83		*
	0700	1.07	9.85	1.27	10.67	1.20	8.83
	1300	0.97	9.48	1.11	10.24	1.13	10.67
	1900	0.95	9.85	1.03	9.85	1.07	10.24
6	0100	0.93	9.85	0.94	9.85	0.92	10.24
	0700	0.89	11.13	0.91	10.67	0.93	10.67
	1300	1.01	11.13	1.12	11.13	1.08	11.13
	1900	0.95	11.64	0.99	11.13	0.90	12.19
7	0100	0.88	11.13	0.98	11.13	0.93	11.13
	0700	0.82	12.19	0.89	12.19	0.95	11.64
	1300	0.86	11.64	0.87	12.19	0.81	12.19
	1900	0.86	12.19	0.81	12.19	0.75	12.80
8	0100	0.71	12.80	0.79	12.80	0.70	12.80
	0700	0.66	12.19	0.65	12.19	0.65	12.80
	1300	0.52	12.19	0.53	12.19	0.50	12.19
	1900	0.47	12.80	0.49	12.80	0.52	12.80
9	0100	0.43	12.19	0.41	11.64	0.43	12.19
	0700	0.36	12.19	0.32	12.19	0.47	11.64
	1300	0.43	2.98	0.34	3.08	0.39	11.64
	1900	0.25	11.64	0.25	11.13	0.26	11.64
10	0100	0.21	9.48	0.22	11.13	0.25	11.13
	0700	0.28	2.12	0.22	13.47	0.26	9.48
	1300	0.52	3.08	0.31	3.12	0.52	2.94
	1900	0.48	4.83	0.49	4.74	0.97	4.74
11	0100	0.52	9.85	0.53	8.00	0.67	7.53
	0700	0.54	7.76	0.57	7.53	0.62	7.53
	1300	0.43	8.83	0.44	9.14	0.57	7.76
	1900	0.51	7.76	0.45	8.00	0.56	7.31
12	0100	0.86	4.49	0.79	4.66	1.08	4.66
	0700	0.93	6.40	0.95	6.40	1.05	6.40
	1300	0.61	6.92	0.62	7.76	0.72	7.31
	1900	0.96	6.92	0.86	6.92	0.99	3.51
13	0100	1.90	5.95	1.83	5.95	2.02	5.95
	0700	2.83	9.48	3.12	9.48	3.52	9.48
	1300	3.21	11.13	3.83	11.64	4.47	11.64
	1900	2.71	12.80	3.19	13.47	3.73	12.80
14	0100	1.68	16.00	1.90	16.00	2.07	16.00
	0700	1.17	16.00	1.24	16.00	1.70	15.06
	1300	0.68	13.47	0.70	14.22	1.08	13.47
	1900	0.65	12.19	0.71	12.19	0.97	12.19
15	0100	0.69	4.74	0.78	13.47	1.09	5.12
	0700	0.87	6.09	1.06	5.95	1.33	5.69
	1300	0.83	4.92	0.90	6.24	0.93	6.40
	1900	0.55	7.76	0.67	14.22	0.67	7.53
16	0100	0.48	8.26	0.55	8.83	0.64	8.26
	0700	0.46	6.74	0.54	7.11	0.56	6.92
	1300	0.64	3.82	0.67	4.20	0.71	4.00
	1900	0.62	4.83	0.65	4.83	0.70	4.92

* Electronic problems

(Continued)

(Sheet 1 of 2)

Table 3: Wave Data

Mar 1993

Day	Hour	625		511		630	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec
17	0100	0.76	5.33	0.87	5.45	1.12	5.69
	0700	0.87	6.40	0.87	6.40	1.12	6.24
	1300	0.92	6.56	1.00	6.56	1.18	6.74
	1900	1.10	6.92	1.10	7.76	1.33	7.53
18	0100	1.71	5.82	2.11	5.69	2.25	5.69
	0700	2.28	7.76	3.07	7.76	2.99	7.76
	1300	2.18	7.76	2.69	8.26	2.82	8.53
	1900	1.91	10.67	2.41	6.24	2.40	7.76
19	0100	2.03	10.24	2.61	9.48	2.77	10.24
	0700	1.93	9.14	2.28	10.24	2.57	10.24
	1300	2.00	9.85	2.43	9.85	2.76	11.13
	1900	1.92	12.80	2.31	10.24	2.25	9.14
20	0100	1.94	9.85	2.27	12.19	1.95	10.67
	0700	1.76	12.19	2.07	12.19	2.04	11.64
	1300	1.65	11.13	1.89	10.67	1.76	11.13
	1900	1.47	11.13	1.70	11.64	1.59	10.67
21	0100	1.19	11.13	1.40	10.67	1.38	10.24
	0700	1.07	10.67	1.19	10.67	1.26	10.24
	1300	1.05	9.85	1.17	10.24	1.16	9.85
	1900	0.92	10.67	1.02	10.24	1.17	10.24
22	0100	0.84	10.67	0.95	9.85	1.07	10.24
	0700	0.84	10.24	0.95	10.67	1.01	9.85
	1300	0.76	11.64	0.91	11.13	0.90	11.13
	1900	0.78	11.64	0.85	10.24	0.85	11.64
23	0100	0.83	11.13	0.84	11.64	0.91	11.13
	0700	0.96	11.13	0.89	11.64	1.01	11.64
	1300	0.83	5.02	0.96	11.13	1.05	11.13
	1900	0.96	5.45	0.95	5.82	1.03	6.24
24	0100	0.80	5.95	0.89	5.82	0.98	6.09
	0700	0.89	6.92	1.01	6.56	1.09	6.40
	1300	0.77	6.92	0.87	6.56	0.99	6.40
	1900	0.80	6.74	0.92	6.56	0.97	6.56
25	0100	0.65	7.31	0.77	6.74	0.86	7.53
	0700	1.27	5.33	1.43	5.33	1.38	5.22
	1300	1.21	6.92	1.29	6.24	1.52	6.24
	1900	0.96	6.40	1.11	6.92	1.24	6.92
26	0100	0.86	7.76	0.93	7.31	0.96	7.53
	0700	0.81	7.31	0.84	7.76	0.92	6.92
	1300	0.63	7.31	0.74	7.31	0.77	7.11
	1900	0.71	7.11	0.71	6.92	0.91	6.92
27	0100	1.01	5.12	0.99	6.74	1.15	4.57
	0700	1.43	5.57	1.43	5.95	1.63	5.57
	1300	1.36	6.56	1.49	7.11	1.75	7.31
	1900	1.38	7.53	1.39	7.31	1.67	7.53
28	0100	1.05	7.76	1.09	7.53	1.24	8.00
	0700	0.87	7.31	0.95	7.53	1.16	7.53
	1300	0.71	7.11	0.79	7.31	0.85	6.74
	1900	0.60	6.92	0.65	6.74	0.75	6.92
29	0100	0.51	7.31	0.53	6.09	0.62	7.31
	0700	0.44	7.76	0.45	6.74	0.52	6.56
	1300	0.40	7.11	0.43	7.11	0.50	7.11
	1900	0.39	9.14	0.43	8.53	0.45	7.76
30	0100	0.38	8.26	0.44	8.26	0.43	8.53
	0700	0.37	7.76	0.40	8.83	0.41	8.00
	1300	0.42	8.26	0.39	9.14	0.51	8.00
	1900	0.33	8.53	0.39	9.14	0.40	8.26
31	0100	0.37	9.14	0.42	8.83	0.44	8.53
	0700	0.38	8.26	0.46	8.83	0.46	8.83
	1300	0.59	9.48	0.67	9.48	0.75	6.09
	1900	0.75	8.53	0.74	7.53	0.90	8.26
	Mean	1.01	9.04	1.11	9.39	1.17	8.89
	Std dev	0.61	3.00	0.74	2.90	0.76	2.87

* Electronic problems

(Sheet 2 of 2)

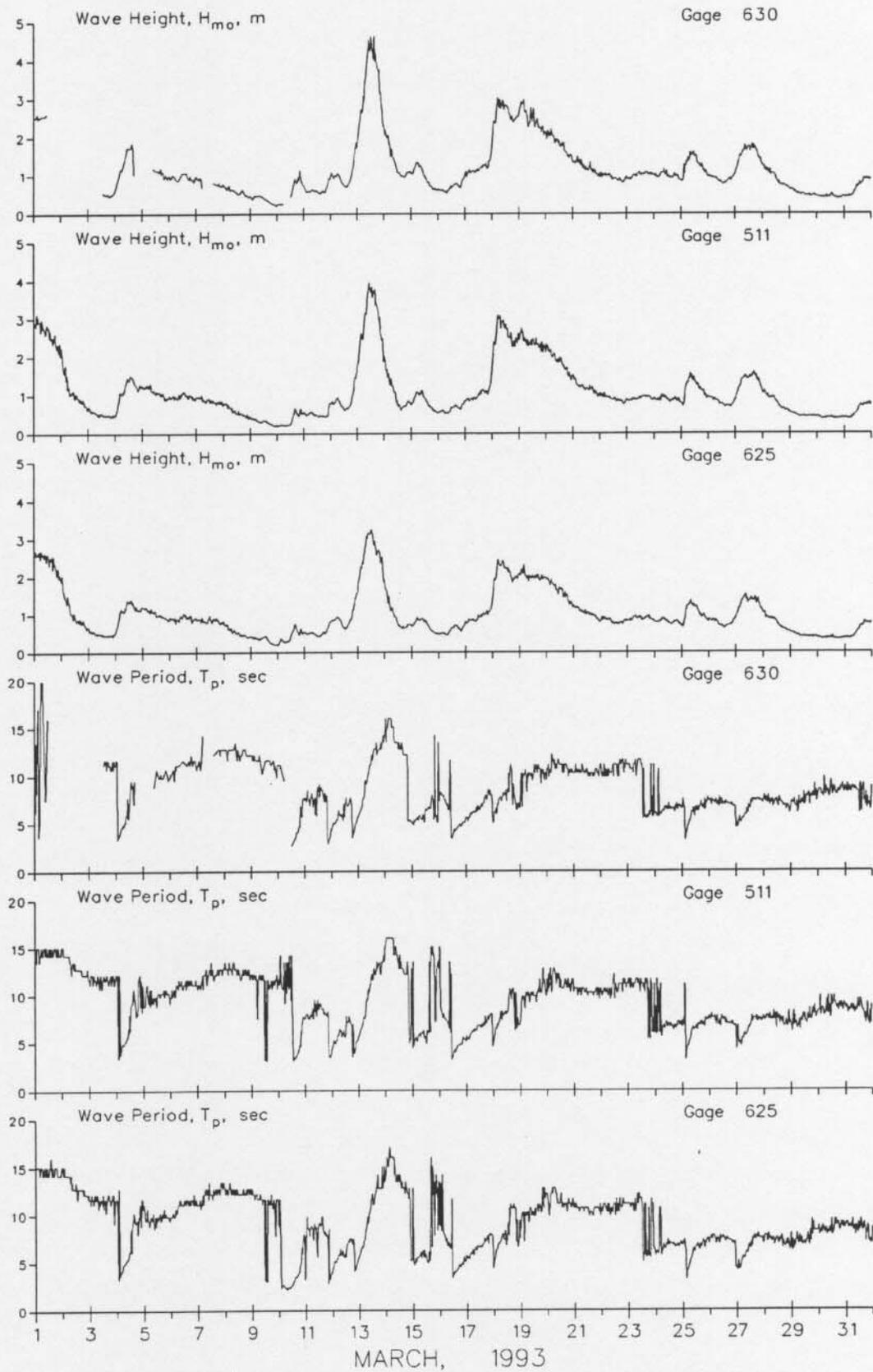


Figure 3. Time history of wave heights and periods

PART IV: CURRENT DATA

Current data (Table 4) are collected from a Marsh-McBirney electromagnetic biaxial current meter (Table 1 and Figure 2) and by visually observing the movement of dye on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier 12 m offshore.

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward).

All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards.

IMPORTANT NOTE

Direction resultants regarding the current meter data (gages 519 and 529) may be in error by 5 degrees due to the uncertainty of the orientation. Please call us if you must use this data.

Table 4: Current Data
Mar 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519		
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface) Distance from Baseline (m)		Dye 12m offshore (surface)			Speed	Dir	
			Speed	Dir	Speed	Dir	Location	Speed	Dir	Speed	Dir	
1	0100	-Along Cross Result									50 19 53	S off 140
1	0700	-Along Cross Result	34 17 38	S on 187	173	61 6 61	S off 154	21	S	North	37 12 39	S off 143
1	1300	-Along Cross Result									44 13 46	S off 144
1	1900	-Along Cross Result									17 1 17	S off 158
2	0100	-Along Cross Result									12 5 13	S off 137
2	0700	-Along Cross Result	0 0 0		165	41 26 48	N off 13	37	N	South	8 3 9	S off 138
2	1300	-Along Cross Result									3 0 3	N 340
2	1900	-Along Cross Result									7 2 7	N off 354
3	0100	-Along Cross Result									12 5 13	N on 318
3	0700	-Along Cross Result	20 6 21	N off 357	165	0 0 0		5	N	South	8 2 8	N on 323
3	1300	-Along Cross Result									9 0 9	N 340
3	1900	-Along Cross Result									2 2 3	S off 116
4	0100	-Along Cross Result									7 1 7	N off 350
4	0700	-Along Cross Result	25 6 26	N on 326	152	61 0 61	N 340	21	N	South	7 1 7	N off 345
4	1300	-Along Cross Result									2 9 9	S on 241
4	1900	-Along Cross Result									14 1 14	S off 157
5	0100	-Along Cross Result									2 2 2	S off 112
5	0700	-Along Cross Result	5 1 5	N off 354	189	76 19 79	N off 354	27	S	South	3 10 11	S off 85
5	1300	-Along Cross Result									6 2 6	S off 144
5	1900	-Along Cross Result									17 1 17	S off 157

KEY = All speeds in cm/sec
 N = Northward, Shore parallel
 S = Southward, Shore parallel
 on = onshore off = offshore

Table 4: Current Data (Continued)
Mar 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519	
			Dye at (579 m) Speed	Dir	Dye at Mid-Surf Zone (surface) Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface) Location	Speed	Dir	Speed
6	0100	-Along Cross Result								20 2 20	S off 155
6	0700	-Along Cross Result	44 13 45	S off 143	165	55 6 56	S on 166	North	44	S 14 33	S off 135
6	1300	-Along Cross Result								29 15 33	S off 133
6	1900	-Along Cross Result								27 14 31	S off 133
7	0100	-Along Cross Result								22 10 24	S off 135
7	0700	-Along Cross Result	16 5 16	S on 177	163	9 7 11	S on 197	North	17	S 6 17	S off 139
7	1300	-Along Cross Result								13 12 18	S off 117
7	1900	-Along Cross Result								3 0 3	N 340
8	0100	-Along Cross Result								7 1 7	N on 328
8	0700	-Along Cross Result	0 0 0		167	9 3 9	N off 357	South	7	8 7 10	N on 301
8	1300	-Along Cross Result								14 8 16	N on 309
8	1900	-Along Cross Result								15 2 15	N off 349
9	0100	-Along Cross Result								1 2 2	S off 94
9	0700	-Along Cross Result	11 19 22	S off 100	166	17 9 19	S off 133	North	11	9 1 9	N on 336
9	1300	-Along Cross Result								3 3 5	N off 29
9	1900	-Along Cross Result								4 11 11	N off 51
10	0100	-Along Cross Result								16 2 16	S off 151
10	0700	-Along Cross Result	4 6 7	S on 220	162	3 7 7	S on 225	North	3	6 4 7	S off 125
10	1300	-Along Cross Result								17 9 20	S off 132
10	1900	-Along Cross Result								3 9 9	N on 265

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Mar 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519		
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface)		Dye 12m offshore (surface)			Speed	Dir	
			Speed	Dir	Distance from Baseline (m)	Speed	Dir	Location	Speed			Dir
11	0100	Along Cross Result								14 7 16	S off 134	
11	0700	Along Cross Result	20 4 20	S off 149	166	23 7 24	S off 143	North	5	N	17 14 22	S off 122
11	1300	Along Cross Result									14 5 14	S off 142
11	1900	Along Cross Result									12 8 14	S off 127
12	0100	Along Cross Result									20 8 22	S off 138
12	0700	Along Cross Result	11 5 12	S on 187	165	41 20 45	S on 187	North	29	S	7 5 8	S off 122
12	1300	Along Cross Result									12 4 12	S off 139
12	1900	Along Cross Result									7 4 8	S off 132
13	0100	Along Cross Result									17 7 18	S off 137
13	0700	Along Cross Result	87 44 97	N on 313	179	152 0 152	N on 340	South	54	N	16 20 26	S off 108
13	1300	Along Cross Result									56 4 56	N off 345
13	1900	Along Cross Result									83 20 86	N on 326
14	0100	Along Cross Result									32 12 34	N on 319
14	0700	Along Cross Result	10 21 24	S off 95	140	20 2 20	N off 346	South	15	N	9 0 9	S on 160
14	1300	Along Cross Result									7 5 9	N on 304
14	1900	Along Cross Result									9 3 9	N on 318
15	0100	Along Cross Result									5 1 5	N on 331
15	0700	Along Cross Result	23 0 23	S off 160	165	61 18 64	S on 177	North	47	S	8 1 8	S off 151
15	1300	Along Cross Result									15 4 16	N off 356
15	1900	Along Cross Result									32 6 33	N on 330

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Continued)
Mar 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519		
			Dye at (579 m) (surface) Speed	Dir	Dye at Mid-Surf Zone (surface) Distance from Baseline (m)	Speed	Dir	Dye 12m offshore (surface) Location	Speed	Dir	Speed	Dir
16	0100	-Along Cross Result									19 8 20	N on 316
16	0700	-Along Cross Result	24 11 27	N on 316	163	20 2 20	N on 334	South	9	N	16 4 17	N on 326
16	1300	-Along Cross Result									18 1	N 340
16	1900	-Along Cross Result									9 5 10	N on 311
17	0100	-Along Cross Result									19 4 19	N on 329
17	0700	-Along Cross Result	34 5 34	N on 331	165	14 4 15	N on 326	South	46	N	19 2 19	N off 347
17	1300	-Along Cross Result									19 5 19	N on 324
17	1900	-Along Cross Result									5 9 11	N on 280
18	0100	-Along Cross Result									52 16 54	S off 143
18	0700	-Along Cross Result	203 10 203	S on 163	189	102 5 102	S on 163	North	37	S	88 28 92	S off 143
18	1300	-Along Cross Result									71 23 75	S off 142
18	1900	-Along Cross Result									60 21 64	S off 141
19	0100	-Along Cross Result									54 19 57	S off 140
19	0700	-Along Cross Result	55 0 55	S 160	175	61 6 61	S off 154	North	15	S	56 21 60	S off 139
19	1300	-Along Cross Result									56 18 59	S off 143
19	1900	-Along Cross Result									49 12 50	S off 146
20	0100	-Along Cross Result									46 10 47	S off 148
20	0700	-Along Cross Result	20 3 20	S off 151	175	76 11 77	N off 349	South	10	N	42 11 43	S off 146
20	1300	-Along Cross Result									31 15 34	S off 134
20	1900	-Along Cross Result									23 12 26	S off 132

KEY = All speeds in cm/sec
N = Northward, Shore parallel
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Table 4: Current Data (Continued)
Mar 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519	
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface)		Dye 12m offshore (surface)			Speed	Dir
			Speed	Dir	Distance from Baseline (m)	Speed	Dir	Location	Speed		
21	0100	Along Cross Result								20 0 20	S 160
21	0700	Along Cross Result	24 7 25	S on 177	163	32 3 32	N on 334	South	8	2 2 2	N on 295
21	1300	Along Cross Result								4 1 4	N on 330
21	1900	Along Cross Result								6 0 6	N 340
22	0100	Along Cross Result								10 1 10	N on 335
22	0700	Along Cross Result	0 0 0		163	68 3 68	N off 343	South	15	15 1 15	N 340
22	1300	Along Cross Result								11 1 11	N on 334
22	1900	Along Cross Result								14 4 15	N on 325
23	0100	Along Cross Result								4 4 5	S off 117
23	0700	Along Cross Result	23 5 24	S on 171	166	44 4 44	N on 334	South	13	7 5 8	S off 125
23	1300	Along Cross Result								17 1 17	S off 158
23	1900	Along Cross Result								9 1 9	N on 334
24	0100	Along Cross Result								5 0 5	N 340
24	0700	Along Cross Result	41 10 42	N off 354	152	41 10 42	N off 354	South	24	6 2 6	N on 322
24	1300	Along Cross Result								3 1 3	N 340
24	1900	Along Cross Result								9 1 9	N off 346
25	0100	Along Cross Result								7 4 8	S off 129
25	0700	Along Cross Result	51 0 51	S 160	176	76 8 77	S off 154	North	56	32 9 33	S off 144
25	1300	Along Cross Result								42 16 45	S off 139
25	1900	Along Cross Result								37 14 40	S off 139

KEY = All speeds in cm/sec
N = Northward, Shore parallel
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on = onshore off = offshore

Table 4: Current Data (Continued)
Mar 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519		
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface)		Dye 12m offshore (surface)			Speed	Dir	
			Speed	Dir	Distance from Baseline (m)	Speed	Dir	Location	Speed	Dir	Speed	Dir
26	0100	Along Cross Result									22 6 23	S off 144
26	0700	Along Cross Result	51 0 51	S 160	163	24 1 24	S off 157	North	23	S	12 4 13	S off 140
26	1300	Along Cross Result									7 6 9	S off 123
26	1900	Along Cross Result									3 3 4	N on 295
27	0100	Along Cross Result									6 5 8	S off 120
27	0700	Along Cross Result	27 9 28	S on 179	164	61 3 61	N off 343	North	12	N	26 6 26	S off 147
27	1300	Along Cross Result									18 4 18	S off 147
27	1900	Along Cross Result									24 6 25	S off 146
28	0100	Along Cross Result									23 8 25	S off 140
28	0700	Along Cross Result	12 0 12	S 160	140	22 22 31	N off 25	South	20	N	21 6 22	S off 144
28	1300	Along Cross Result									22 9 24	S off 137
28	1900	Along Cross Result									16 3 16	S off 149
29	0100	Along Cross Result									2 4 5	S off 92
29	0700	Along Cross Result	19 1 19	S off 157	165	8 1 8	S off 154	North	3	N	6 2 7	S off 143
29	1300	Along Cross Result									10 3 11	S off 143
29	1900	Along Cross Result									0 1 1	 on 250
30	0100	Along Cross Result									31 7 32	S off 147
30	0700	Along Cross Result	68 3 68	S off 157	168	23 6 23	S off 146	North	17	S	18 6 19	S off 141
30	1300	Along Cross Result									39 16 42	S off 137
30	1900	Along Cross Result									39 18 43	S off 135

KEY = All speeds in cm/sec
N = Northward, Shore parallel
S = Southward, Shore parallel
on = onshore off = offshore

Table 4: Current Data (Concluded)
Mar 1993

Day	Time	Alongshore Cross-shore Resultant	Pier Measurements				Beach Measurements (500m Updrift)			Current Meter 0.9 km Offshore Depth -5.6m (NGVD) ID #519		
			Dye at (579 m) (surface)		Dye at Mid-Surf Zone (surface)		Dye 12m offshore (surface)			Speed	Dir	
			Speed	Dir	Distance from Baseline (m)	Speed	Dir	Location	Speed	Dir	Speed	Dir
31	0100	Along									17	S
		Cross									5	off
		Result									18	143
31	0700	Along	29	S		9	N		2	N	10	S
		Cross	4	off	162	6	on	South			3	off
		Result	29	151		11	303				11	143
31	1300	Along									23	S
		Cross									3	off
		Result									23	152
31	1900	Along									19	S
		Cross									8	off
		Result									20	137

KEY = All speeds in cm/sec
 N = Northward, Shore parallel
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PART V: SUPPLEMENTAL OBSERVATIONS

Visual wave direction measurements (Table 5) of both the primary wave train (i.e. that having the larger wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 5: Supplemental Observations

Mar 1993

Day	Time	Wave Approach Angle at Pier End deg from True N		Radar Wave Angle deg from True N	Width of Surf Zone, m	Water Characteristics at Pier End		
		Primary	Secondary			Temp., C	Density g/cc	Secchi Vis., m
1	0815	65	35	65	284	3.9	1.0240	0.3
2	0745	75			193	4.0	1.0240	0.6
3	0745	70	110		138	4.6	1.0240	1.2
4	0900	80	75	50	140	5.3	1.0242	0.6
5	0900	40			146	4.7	1.0249	0.9
6	0835	70	20		136	4.6	1.0248	0.9
7	0850	70	95	70	157	5.6	1.0222	1.8
8	0900	70	25		118	5.0	1.0239	1.5
9	0730	5	140		4	5.7	1.0231	2.1
10	0735	55			2	6.5	1.0218	2.4
11	0737	85	5		2	6.7	1.0204	2.1
12	0830	20		45	61	6.7	1.0196	1.5
13	1200	100		100	753	7.2	1.0195	0.3
14	0930	90		90	285	4.5	1.0248	0.3
15	0730	35		35	143	4.4	1.0244	0.3
16	0830	80		75	138	4.8	1.0243	0.3
17	0820	100			160	6.5	1.0242	0.9
18	0920	30		45	398	5.6	1.0250	0.3
19	0740	40		50	355	4.4	1.0220	0.3
20	1150	75		75	378	5.1	1.0196	0.0
21	1025	70			221	5.7	1.0179	0.3
22	1010	70		95	150	6.7	1.0202	0.6
23	0740	95		95	136	7.2	1.0185	1.2
24	0910	80			93	6.7	1.0221	1.2
25	0750	40		40	155	5.6	1.0232	0.6
26	0745	70	30		122	6.7	1.0170	0.9
27	1100	65		95	195	7.4	1.0161	0.6
28	0930	65			384	7.8	1.0194	0.9
29	0750	70	100		15	9.0	1.0163	1.2
30	0740	25			4	8.9	1.0160	0.9
31	0735	75	65		12	8.4	1.0151	0.9

PART VI: WATER LEVELS

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A Leupold-Stevens digital recording float-type tide gage is used to collect instantaneous water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 4 along with a list of mean and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level.

Table 6 contains the time at the center of each 12.42-hr tidal cycle and the range, high, low, and mean water levels during each tidal cycle.

FRF Tide Heights

Mar 1993

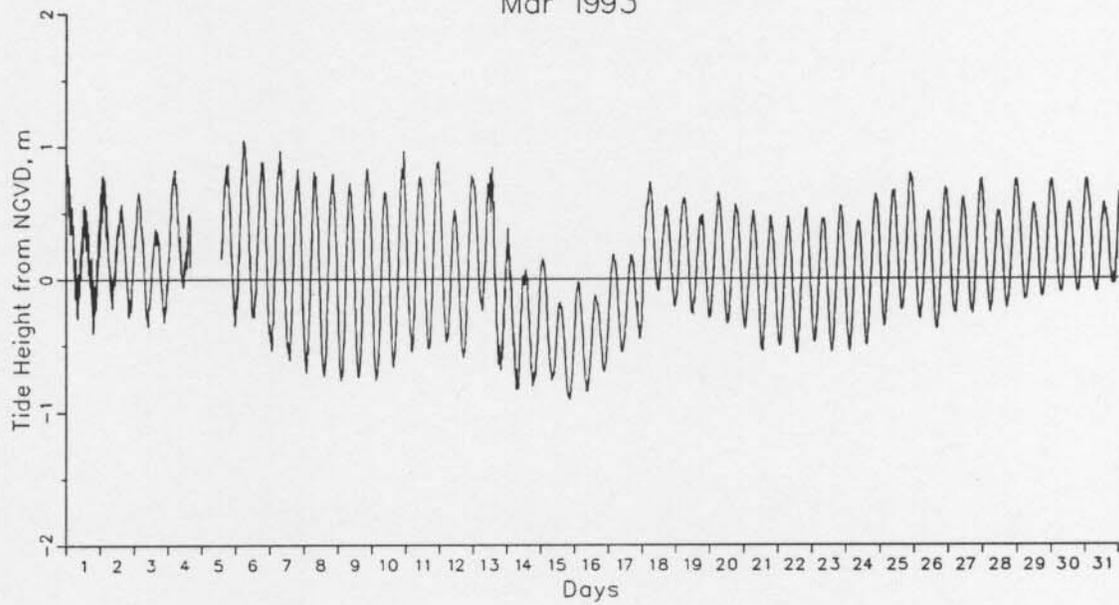


Figure 4. Water level time history

Monthly Water Levels, m NGVD

Extreme Low = -0.91 on day 15 at 2000 EST
Extreme High = 1.05 on day 6 at 442 EST
Monthly Mean = 0.08
Mean Low = -0.44
Mean High = 0.64
Mean Range = 1.08

Table 6: Water Levels, m NGVD

		Mar 1993			
Mid-Cycle	Low	High	Mean	Range	
Day	Time				
1	500	-0.30	0.87	0.25	1.17
1	1725	-0.41	0.79	0.16	1.19
2	550	-0.22	0.77	0.25	0.99
2	1815	-0.29	0.62	0.17	0.91
3	640	-0.36	0.66	0.13	1.01
3	1906	-0.33	0.77	0.13	1.09
4	731	-0.06	0.83	0.34	0.89
4	1956	Gage Inoperative			
5	821				
5	2046	-0.35	0.93	0.32	1.28
6	912	-0.29	1.05	0.33	1.34
6	2137	-0.54	0.89	0.18	1.43
7	1002	-0.61	0.97	0.13	1.58
7	2227	-0.70	0.83	0.06	1.54
8	1052	-0.73	0.81	0.03	1.54
8	2318	-0.76	0.80	0.01	1.56
9	1143	-0.74	0.75	0.00	1.49
10	8	-0.77	0.84	0.01	1.60
10	1233	-0.66	0.71	0.04	1.37
11	58	-0.55	0.97	0.17	1.52
11	1324	-0.52	0.79	0.14	1.31
12	149	-0.48	0.89	0.16	1.37
12	1414	-0.59	0.68	-0.01	1.27
13	239	-0.24	0.78	0.30	1.02
13	1504	-0.69	0.85	-0.01	1.53
14	330	-0.83	0.39	-0.28	1.22
14	1555	-0.80	0.07	-0.36	0.87
15	420	-0.76	0.15	-0.34	0.91
15	1645	-0.91	-0.18	-0.54	0.73
16	510	-0.85	-0.02	-0.44	0.83
16	1735	-0.70	-0.01	-0.37	0.69
17	601	-0.55	0.19	-0.18	0.74
17	1826	-0.45	0.42	-0.05	0.87
18	651	-0.09	0.73	0.31	0.83
18	1916	-0.21	0.55	0.18	0.77
19	741	-0.27	0.62	0.18	0.88
19	2007	-0.30	0.49	0.12	0.79
20	832	-0.34	0.66	0.14	0.99
20	2057	-0.38	0.56	0.10	0.94
21	922	-0.55	0.52	-0.01	1.06
21	2147	-0.51	0.48	-0.01	0.98
22	1013	-0.56	0.47	-0.04	1.04
22	2238	-0.48	0.53	0.02	1.01
23	1103	-0.55	0.46	-0.02	1.01
23	2328	-0.54	0.55	0.01	1.09
24	1153	-0.50	0.59	0.04	1.09
25	19	-0.36	0.64	0.17	1.00
25	1244	-0.24	0.78	0.25	1.02
26	109	-0.30	0.80	0.20	1.10
26	1334	-0.38	0.68	0.11	1.06
27	159	-0.26	0.69	0.19	0.95
27	1425	-0.26	0.74	0.20	1.01
28	250	-0.26	0.76	0.21	1.01
28	1515	-0.22	0.76	0.21	0.98
29	340	-0.16	0.75	0.25	0.91
29	1605	-0.13	0.75	0.26	0.88
30	431	-0.10	0.75	0.28	0.85
30	1656	-0.10	0.76	0.28	0.86
31	521	-0.10	0.76	0.28	0.85
31	1746	-0.04	0.65	0.26	0.69

PART VII: NEARSHORE PROFILES

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 5 shows the last survey in February 1993 and the surveys in March 1993 on profile line 188, located 517 m south of the pier.

The profile envelope (Figure 6) reflects the maximum changes that occurred on the profile during 1993. Cross-hatched areas indicate changes to the annual envelope which occurred in March.

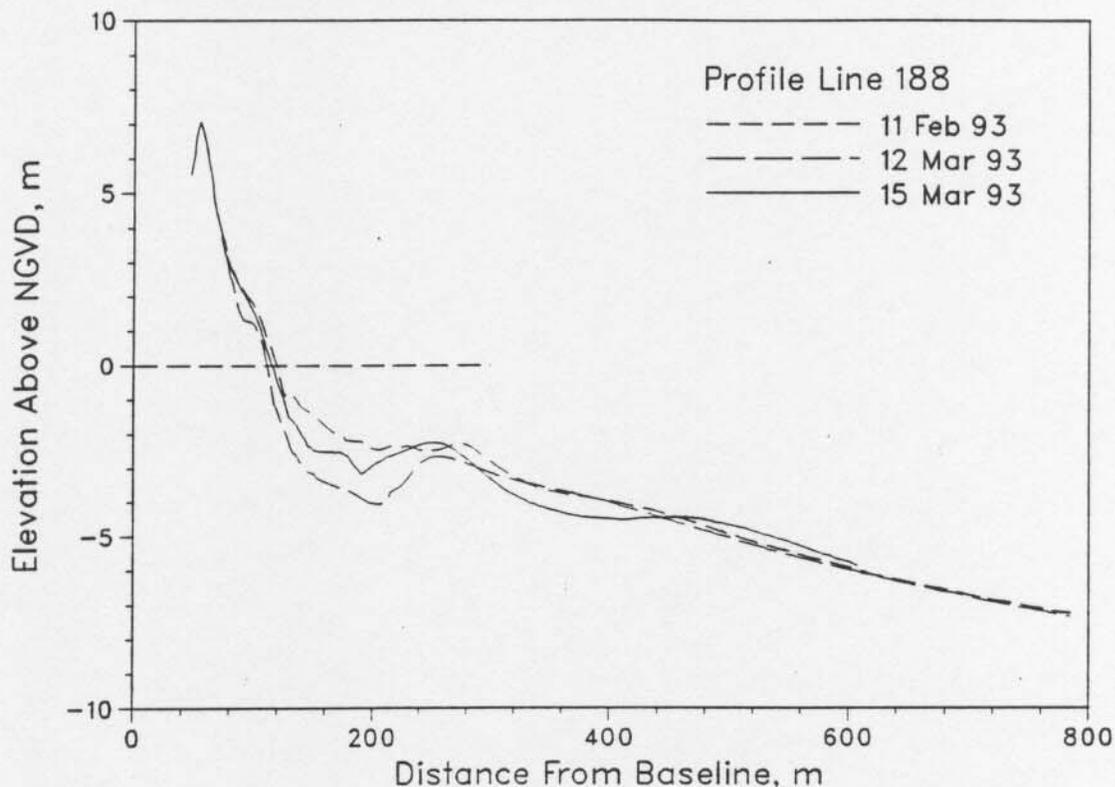


Figure 5. Monthly CRAB profiles on profile 188 - 517 m south of pier.

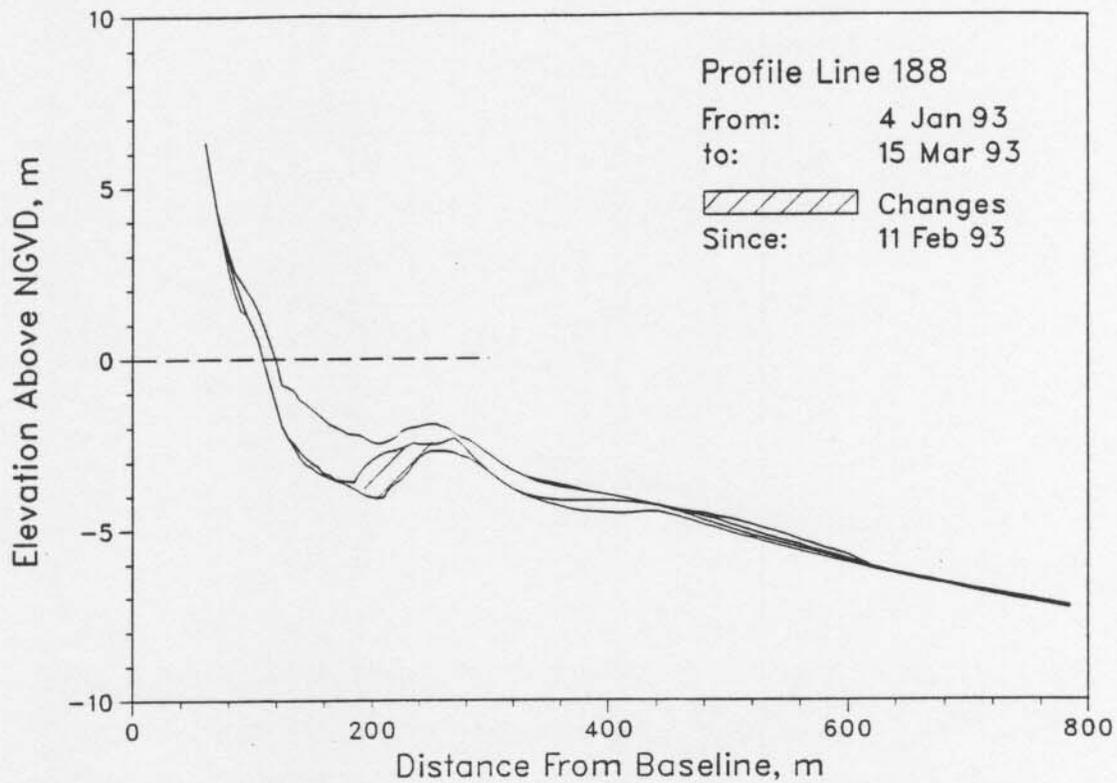


Figure 6. CRAB profile envelope - profile 188.

B. Bathymetry. Figure 7 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 16 March. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

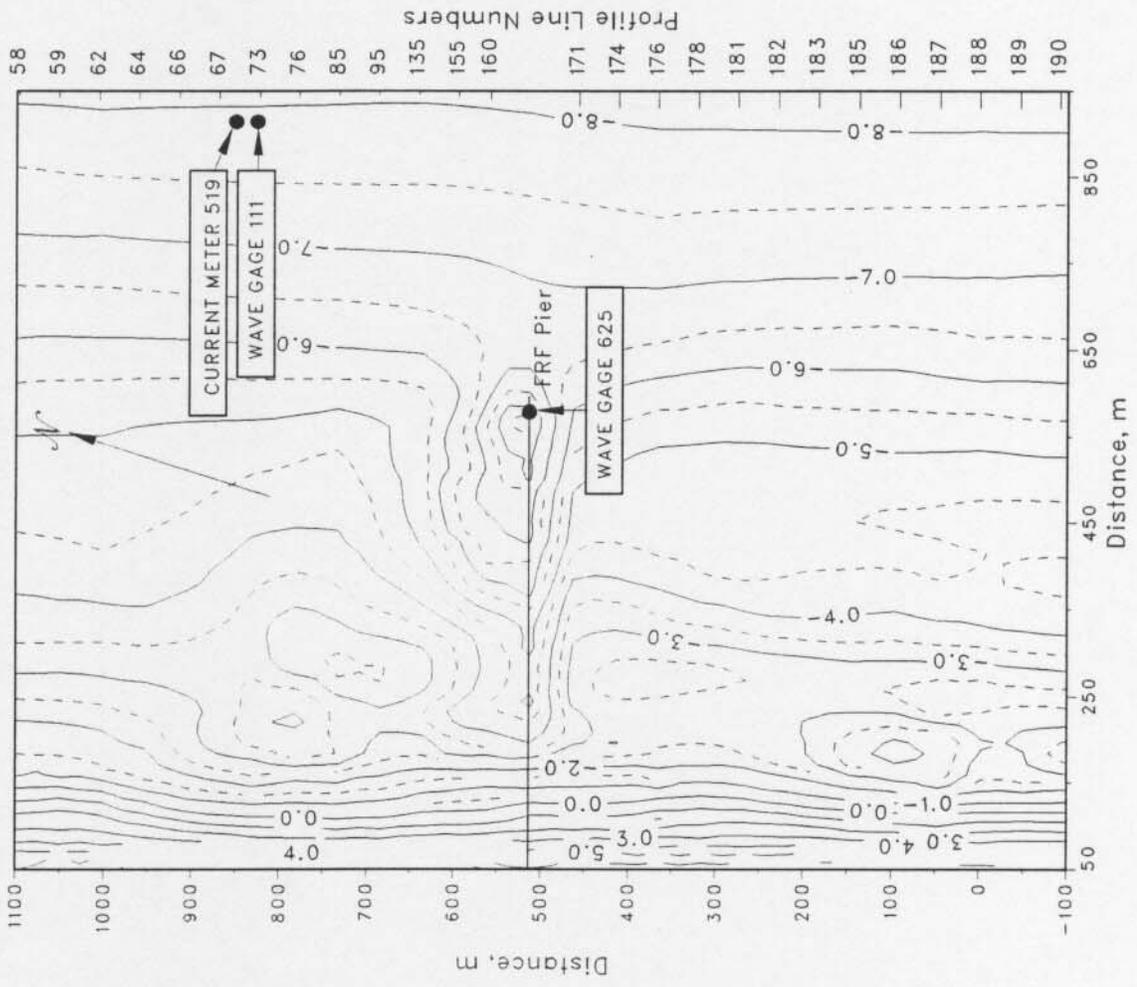
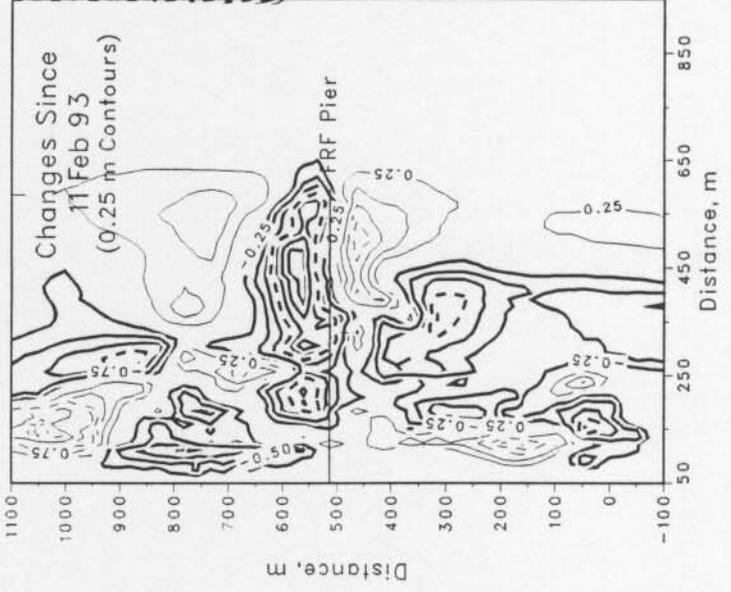
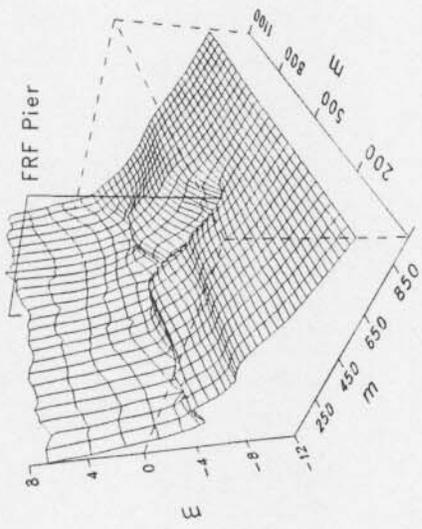


Figure 7. FRF bathymetry 16 Mar 93 depths relative to NGVD

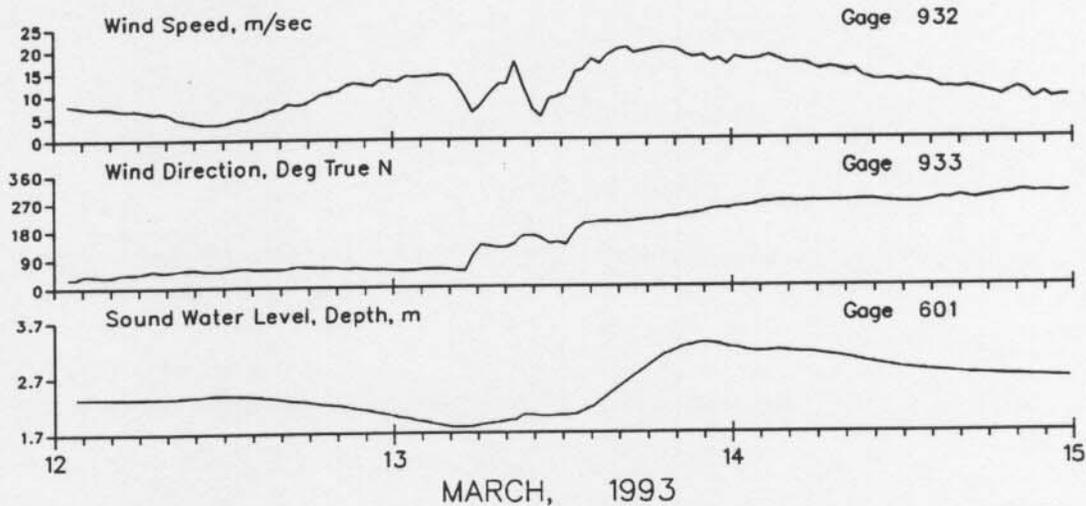
PART VIII. SPECIAL EVENTS

A. Storm Data Collection. The following list identifies times when the wave height H_{mo} at the seaward end of the pier (i.e. as measured near the end of the pier) exceeded 2 m.

<u>Start</u>	<u>End</u>
13 March (0208)	13 March (2234)
18 March (0400)	19 March (2008)

B. Storm Synopsis.

13 March - Known locally as the "March 13 Storm", this storm caused some of the worst sound side flooding this century. A low pressure system formed over the southernmost tip of Texas on the morning of 12 March. Moving east the storm continued to strengthen, finally crossing Florida into the Atlantic on the morning of 13 March and turning to the Northeast. The storm's center passed about 160km west of the FRF. Winds came dominantly from the west reaching sustained speeds of 20 m/s. These strong westerly winds piled the water in the sound up against the Outer Banks. Soundside flooding was extensive. FRF data indicates a 1.3m storm surge in the sound. Many roads were washed away or inundated, making travel impossible. There was considerable sound-side erosion and water damage to homes. The FRF LARC (a large amphibious vehicle) and several members of the FRF staff (Brian Scarborough, Ray Townsend, Bill Birkemeier) assisted other emergency personnel in rescue operations during the height of the storm. Waves on the ocean side, reached a maximum H_{mo} of 4.6 m ($T_p = 12.19$ s) at 1216 EST, at gage 630. The atmospheric pressure dropped to 970 mb. There was 57 mm of precipitation.



18-19 March - Northerly winds associated with a high pressure system over Quebec, reached 18.0 m/s at 0700 EST on 18 March. Waves at gage 625 reached a maximum H_{mo} of 2.4 m ($T_p = 8.26$ s) at 916 EST on 18 March. Atmospheric pressure rose to 1033 mb. There was 14 mm of precipitation.

Distribution List

Government Agencies:

Back Bay National Wildlife Refuge	U.S. Geological Survey
USACE-OCE	U.S. Library of Congress
USACE-SAD	U.S. National Park Service
USACE-NAP	U.S. National Weather Service
USACE-SAW	U.S. Naval Academy
USACE-WES	U.S. Naval Civil Eng. Lab
NAVSAC	U.S. Naval Oceanographic Off.
NOAA/NOS/OMS	U.S. Naval Research Lab
National Marine Fisheries	

Colleges/Universities:

Bucknell University	Scripps Institution of Oceanography
California Inst. of Tech.	Stockton State College
Duke Marine Lab	University Calif-Berkeley
East Carolina University	University of Florida
Florida Inst. of Tech.	University of Maryland-College Park
M.I.T.	University of Maryland-Baltimore
Naval Post Graduate School	University of North Carolina
NC State University	University of N C-Seagrant Program
Old Dominion University	University of Virginia
Oregon State University	Va. Inst. of Marine Science
Prince George's College	Rutgers University

Others:

Allied Signal Aerospace Co.	WCTI-TV
Applied Physics Lab	MEC Systems Corporation
Cape Hatteras Nat. Seashore	Moffatt & Nichol, Eng.
Coastal and Est. Res., Inc.	N.C. Div. Coastal Management
Coastal Science & Eng., Inc.	Oregon Inlet & Waterways Commission
Dr. Cy Galvin	Raleigh-Durham Airport
GEOMET Tech., Inc.	Mr. Rowland
Mr. Hodges	Mr. Savage
Dr. Hylton	Science Application Int'l. Corp
Mr. Mason	Sherwood Industries
Mr. Rodgers	SEASUN Power Systems

Foreign:

Christchurch, Barbados
Ministry of Works, Bahamas
Dalhousie University, Halifax Nova Scotia
Queen's University, Ontario (Canada)
Ministry of Construction, Coastal Division (Japan)
Norwegian Hydrodynamic Laboratories (Norway)
University of Sydney (Australia)